
Anne Phillips U.S. Geological Survey

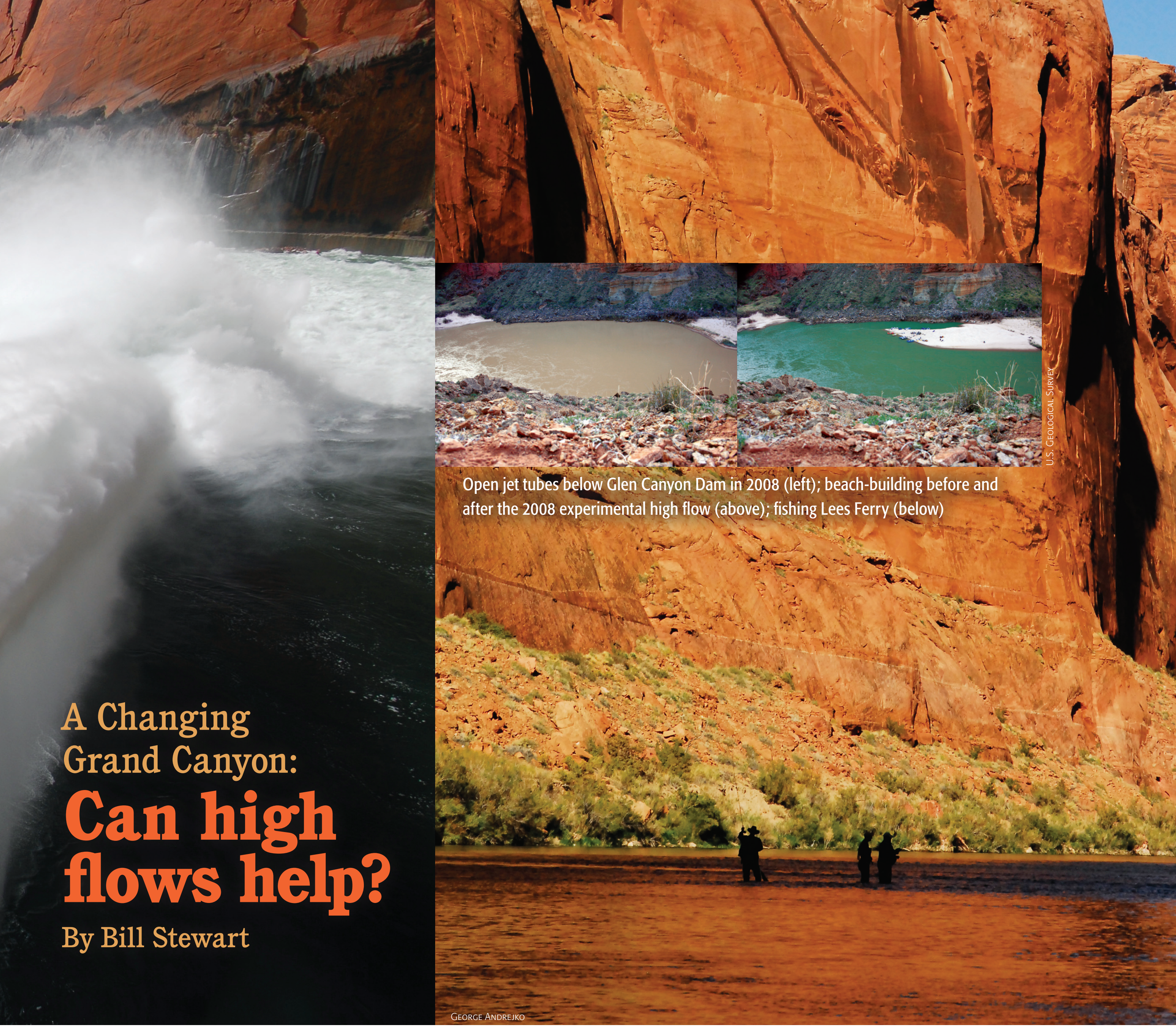
Glen Canyon Dam in northern Arizona marks the start of more than 300 miles of uninterrupted Colorado River, running through one of the seven natural wonders of the world: the Grand Canyon. Completed in 1963, Glen Canyon was created to store water, control floods and generate hydroelectricity.

If not for dams such as Glen Canyon and Hoover, many of us would likely not be living in Arizona. However, like many dams, Glen Canyon Dam dramatically changed the ecosystem downstream. The dramatic changes forever altered conditions for the native fishes of the Colorado River — changes resource managers are still grappling with today.

A River Changed

Those who rafted the Grand Canyon before the dam was built experienced a river that is much different than today. Prior to the construction of Glen Canyon Dam, the Colorado River was dynamic. In any given year, flows ranged from less than 1,000 cubic feet per second to more than 100,000 cfs, water temperatures went from near freezing in winter to above 85° in summer, and the river went from being laden with turbid, brown sediment to flowing with very clear water.

The river's native fish species, such as the humpback chub and razorback sucker, adapted to this natural environment. To forage effectively in turbid waters, they developed hump-like structures, which are thought to help them maintain position in the wild Colorado River. But following construction of the dam, water flows became regulated such that they rarely get above 31,500 cfs



Open jet tubes below Glen Canyon Dam in 2008 (left); beach-building before and after the 2008 experimental high flow (above); fishing Lees Ferry (below)

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A Changing Grand Canyon: Can high flows help?

By Bill Stewart

(maximum power-plant capacity) and do not typically fall below 5,000 cfs.

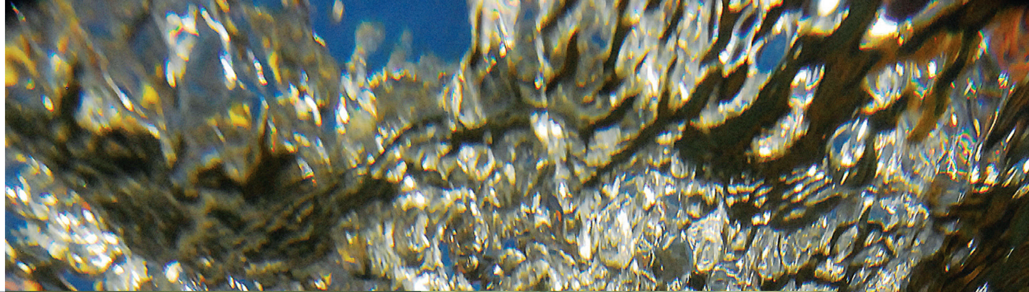
Water also is now discharged at relatively cool, steady temperatures between 45° and 50°. This is because water below Glen Canyon Dam is drawn year-round from near the bottom of Lake Powell using deep, fixed-level penstock intakes. The dam also impacts sediment, which affects our fisheries and other natural resources. Sediment coming from the upper Colorado River now gets trapped behind the dam, so below the dam we are left with a river that is cold, clear and largely free of sediment.

And sediment matters, to people and to fish. Beaches are especially important, not just to rafters wanting a good spot to camp, but to riparian vegetation and the wildlife that depend on it for shelter. Under post-dam conditions, beaches are slowly eroding away. Historically, floods typically replenished the beaches along the river's shore with sand: Sand that is now held behind the dam.

The post-dam environment has been hard on some of our native fish species. The cold, clear, stabilized flows are not the environment to which they adapted. As a result, three of the eight native fish species in the Grand Canyon have been extirpated and another, the razorback sucker, is on the verge.

The environmental changes have not been all bad, however. The cool, clear water flowing from the dam has created one of the best tailwater rainbow trout fisheries in the nation at Lees Ferry. Anglers come from across the nation to test their fly-fishing skills in some of the most beautiful country in the world.

In May 2012, after two years of thorough analysis, the Bureau of Reclamation developed a protocol for experimental high flows designed to improve condi-



> **To forage effectively in turbid waters, they developed hump-like structures, which are thought to help them maintain position in the wild Colorado River.**

Humpback Chub

Razorback Sucker

Photos by George Andrejko

tions in the Grand Canyon. Designed with assistance from several cooperators, including the Arizona Game and Fish Department, these experimental flows are intended primarily to conserve sediment input from tributary streams. For the purpose of the protocol, a high flow is considered any dam release of water that ranges from 31,500 to 45,000 cfs.

Learning From the Past

High flow experiments with Glen Canyon Dam are not new. In fact, three have been conducted in the past, and much has been learned about each one.

1996 high flow: The first high flow was held from March 26 to April 8, 1996. Flows were gradually increased from 8,000 cfs to 45,000 cfs and held for a seven-day period. At the time, monitoring was primarily focused on sediment, but it turned out these high flows were doing interesting things for fish species, as well.

This experiment was conducted when the Colorado River was relatively sand-depleted and as a result, the sand used for building high-elevation beaches (good for camping) was coming from the lower-elevation parts of upstream sandbars, not from sand within the river channel. This essentially kicked out the foundation of upstream sandbars, causing them to erode quickly.

Scientist and managers realized that to prevent sandbars from eroding during high flows, they must take advantage of the tributary floods that supply new sand to the system, particularly sand input from the Paria River just below Lees Ferry and the Little Colorado River 60 miles downstream.

2004 high flow: This experiment was held November 21–23, 2004, and included a 60-hour release of 41,000 cfs. It was conducted during a period of sediment-enriched conditions shortly after the Paria River delivered a large amount of sediment. Results from this experiment showed that a shorter-duration high flow (60 hours, as compared to seven days) could quickly build beaches. But it also showed that beaches tend to erode in a relatively short period following the high flow (eroding within a period ranging from days to several months).

2008 high flow: The third high flow was held March 5–7, 2008, and included

For more information on the High Flow Experimental Protocol, visit the Bureau of Reclamation's website, www.usbr.gov/uc/envdocs/ea/gc/HFEProtocol.

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a 60-hour release of 41,500 cfs. This high flow was timed to take advantage of the highest sediment deposits in a decade. It was designed to better assess the ability of these releases to rebuild sandbars and beaches that could provide habitat for riparian wildlife and native fish (particularly humpback chub) and campsites for Grand Canyon recreationists. Similar to the 2004 high flow, this high flow was successful at building sandbars, but showed that flows and sediment input following the high flow can influence rates of erosion.

High Flows and Rainbow Trout

During the first two high flow experiments, sediment conservation and beach building were the primary resources being studied. However, a research project during the 2008 high flow experiment on juvenile rainbow trout discovered some interesting results. Following the spring 2008 high flow, a fourfold increase in juvenile trout was observed. This response persisted into 2009, when juvenile survival was two times that of pre-high flow years.

Also during this period, researchers at the U.S. Geological Survey's Grand Canyon Research and Monitoring Center observed an increase in midges and black flies, which are high-quality food items for rainbow trout. The increase in high-quality food likely led to an increase in juvenile trout survival. A similar response had been detected during the spring 1996 high flow, although at the time, it was not understood why.

The exceptionally high juvenile survival in 2008 and 2009 has led to great fishing and some of the highest catch rates at Lees Ferry in over a decade. However, overcrowding increases competition for those once-abundant midges and black flies, and could cause a decrease in trout condition, reduced growth and dispersal downstream, where there is the potential for negative interactions between rainbow trout and the endangered humpback chub.

The New High Flow Protocol

The Bureau of Reclamation, in coordination with the Arizona Game and Fish Department and nine other cooperating agencies, developed a protocol to evaluate short-duration, high-volume dam releases during sediment-enriched conditions for a 10-year period of experimentation, 2011–2020, to determine how multiple events can be used to better build sandbars and conserve sand.

This protocol is designed to build off the previous high flow experiments by testing how timing, magnitude and duration of high flows affect beach building. Beaches are very important for the ecosystem. They create backwater habitats, which can provide key wildlife habitat; potentially reduce erosion of archaeological sites; enhance riparian vegetation, another key habitat; maintain or increase camping opportunities; and improve the wilderness experience along the Colorado River in Grand Canyon National Park.

The decision to conduct a high flow largely depends on sediment input from the Paria and Little Colorado rivers. To take advantage of sediment inputs, two sediment accounting periods, January through March and July through October, will track input from the two tributaries. If sediment accumulation in the Colorado River is high, then high flows may be conducted during two windows: March–April and October–November. Even if sediment input is high, other resources (such as the status of humpback chub, rainbow trout and riparian vegetation) will be addressed before a final decision is made.

There is still much to learn about the impacts of high flows on our resources. During each high flow experiment conducted in the past, scientists learned something new. In previous experiments, spring high flows did good things for rainbow trout recruitment, but questions remain about the impacts of fall high flows on trout and their food base. Also, little is known about the cumulative effects of high flows. The impacts of back-to-back high flows on physical and biological resources are largely unknown.

What we do know is that the impacts of these flows will continue to be monitored, and resource managers will continue to use the newest information to make informed decisions. We want to ensure that future generations can continue to enjoy a fly-fishing experience at Lees Ferry that is unlike any other, marvel at the splendor of the endangered humpback chub or have the thrill of a lifetime rafting down the Colorado River through the Grand Canyon.

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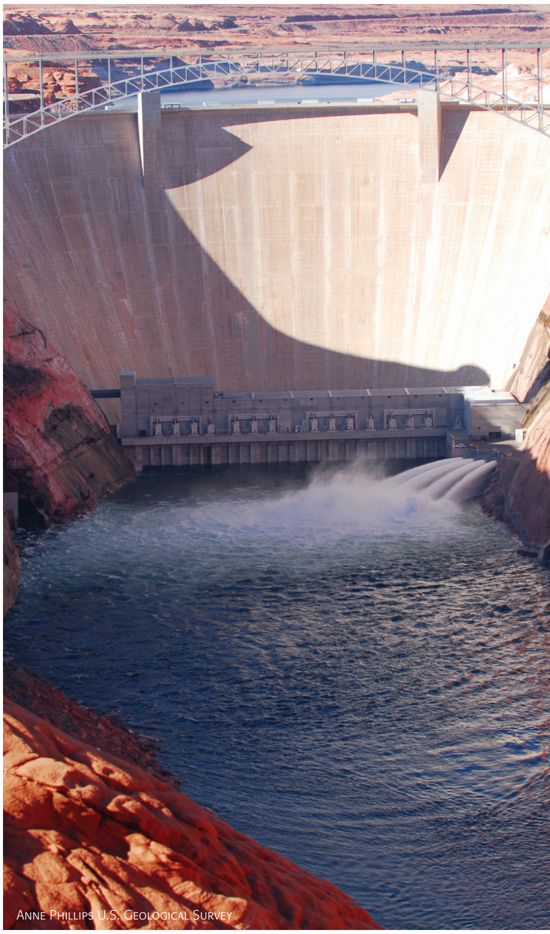
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